

**Analysis of Water and Nutrient Budgets
for the Caloosahatchee Watershed**

VERIFICATION OF SUB-BASIN BOUNDARIES

Deliverable for Task 5 of Work Order #1
Cooperative Agreement No. C-7615

by
E.G. Flaig, Senior Engineer & Courtesy Assistant Professor,
P. Srivastava, GIS Specialist,
and
J.C. Capece, Assistant Professor

South Florida Water Management District
and
Department of Agricultural and Biological Engineering
Institute for Food and Agricultural Sciences
University of Florida

Southwest Florida Research and Education Center
Immokalee, Florida

1. SUMMARY

Sub-basin boundaries were developed based on previous basin studies and evaluation of the drainage network for the watershed. A drainage network was developed for the Caloosahatchee Estuary Watershed that located the flowpaths for runoff. The drainage network was used to determine sub-basin boundaries. These boundaries were compared to those delineated in the previous studies. The boundaries were verified using aerial photography, discussions with field engineers and, where possible, field visits. The revised boundaries are very similar to the previous ones. Small changes occur where recent urban and agricultural development have modified the drainage patterns. The uncertainty in the sub-basin boundary coverage ranges from approximately 10 feet for boundaries near roads and other major structures to 500 feet in areas of diffuse sheetflow.

2. INTRODUCTION

One goal of the Caloosahatchee Water Management Plan is to develop a water resources management plan for the Caloosahatchee Watershed. The management plan will address water supply requirements and the volume and timing of runoff. A critical issue will be the effect of alternative land and water management practices on water use and runoff. The impact of alternative management practices can be evaluated for the entire watershed. However, the landuse and water use characteristics of the watershed are spatially heterogeneous, and various alternatives will have different effects depending on location within the watershed. These differences are due to differences in soils, drainage, and landscape. As such, it is necessary to evaluate water use and runoff for several tributaries of the Caloosahatchee River and Estuary. The watershed can be divided into sub-basins for evaluation of land management practices and monitoring discharge.

In this report, the current sub-basin boundaries were reviewed and modified, as necessary, based on review of the hydrography and discussions with District staff. This report includes a modified sub-basin boundary coverage, a description of the modification process, and a coverage indicating the differences between the original coverage and the modified coverage.

3. PRIMARY BASIN BOUNDARIES

The Caloosahatchee Watershed can be delineated into several primary basins (Fig. 1). The primary basins are the East Caloosahatchee, defined as the land that drains into the C-43 canal between Lake Okeechobee and the Ortona Lock and Spillway (S-78); the West Caloosahatchee, defined as the land that drains into the C-43 canal between the Ortona Lock and Spillway and the Franklin Lock and Dam (S-79); Telegraph Cypress Swamp; Orange River; and the Caloosahatchee Estuary, defined as the land that drains to the Caloosahatchee Estuary downstream of Franklin Lock. The Caloosahatchee Estuary Basin can be divided into a tidal portion where tributary stage is affected by the tides, and the estuary portion that is upstream. The primary basin boundaries are the official SFWMD boundaries. These boundaries were developed by the U.S. Army Corps of Engineers as part of the engineering analysis for the C-43 canal design. The boundaries pre-date many changes in the local drainage.

There are several locations where ambiguous or bi-directional drainage affects the Caloosahatchee basin boundaries (Fig. 2). In these areas, the direction of storm water drainage is determined by antecedent water levels, runoff volume, and location of man-made structures. In general, base-flow drainage follows the basin boundaries defined in Figure 1. However, at high water levels or following large storm events, the drainage pattern in these areas is subject to change. For example, a portion of the S-4 basin (also known as the C-21 and S-235 basin) may drain into the Caloosahatchee River. Drainage water from the C-21 canal is released into the Caloosahatchee River through S-235 when the Lake Stage is greater than 15.5 ft or the stage exceeds the lake regulation schedule. The runoff is generated primarily from the Disston Water Control District (DWCD). Stormwater runoff from DWCD may be discharged through the S-4 or S-235 structures or may be discharged into the C-43 canal through a private drainage pump or discharged to Lake Hicpochee through private drainage pumps.

The Caloosahatchee River also captures drainage from Nicodemous Slough when Lake Okeechobee stage is high or runoff exceeds the conveyance capacity of the L19 and L-21 barrow canals. Drainage water is discharged through the C-19 canal into Lake Hicpochee. Under normal conditions Nicodemus Slough drains to Lake Okeechobee.

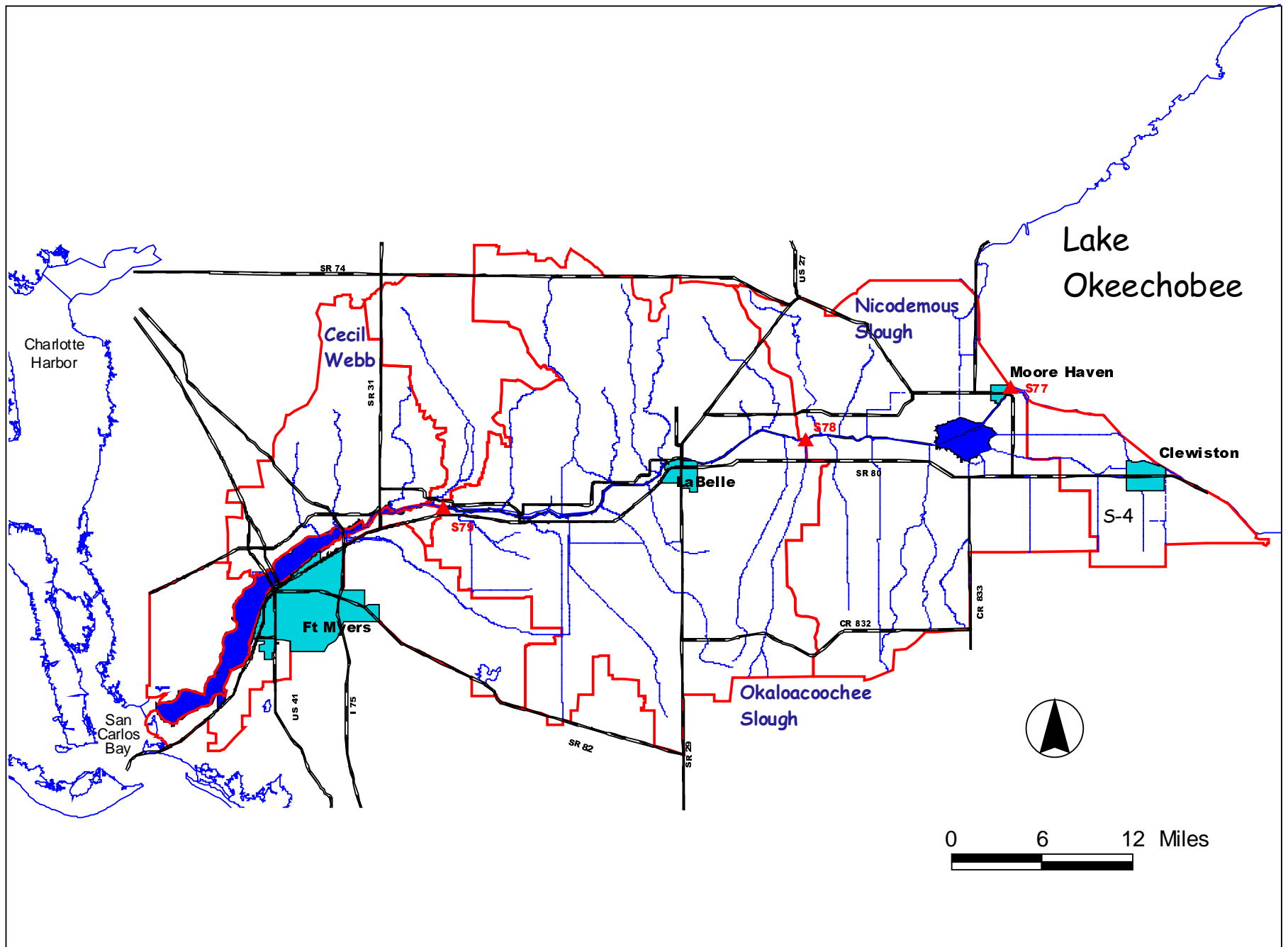


Fig. 2 Regions of ambiguous or bi-directional drainage

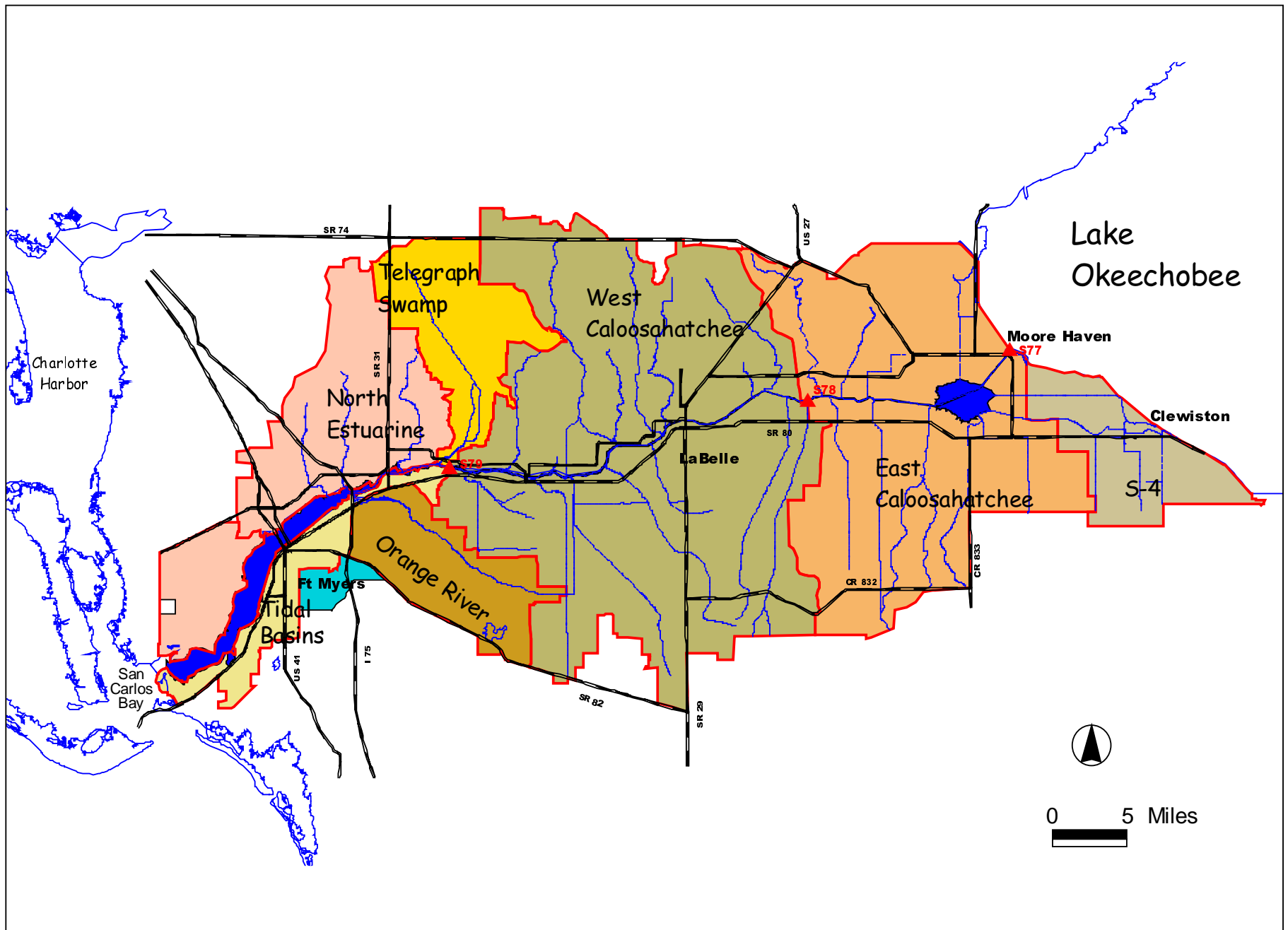


Fig. 1 Primary Drainage Basins of the Caloosahatchee Watershed.

The Caloosahatchee River may capture runoff from other basins due the variable nature of the watershed boundary. Although the boundaries are generally well defined there are two locations, the Okaloacoochee Slough and Cecil Webb Wildlife Management Area, where the watershed is poorly defined. The headwaters of the Okaloacoochee Slough occur along the south edge of the watershed. This area is very poorly drained with a mixture of marsh and swamp habitats. The area can drain northward into the Caloosahatchee River or southward into Fatahatchee Strand. The direction of flow may be dependent on down stream conditions of vegetative growth in the flowpaths and antecedent water levels. Review of historical maps does not clarify the drainage pattern; older maps following available one-foot contour topography establish the watershed boundary in different locations (Task 4 Report). A canal was constructed from SR 832 northward providing a flowpath for drainage originating south of the road. This establishes the watershed boundary south of the road during normal conditions. The exact location is uncertain.

The direction of drainage from the Cecil Webb Wildlife Management Area also depends on the antecedent water conditions of the area. The drainage from this area is split: it flows south to the Caloosahatchee and west to Matlacha Pass. With urban development, canals have been dug inland from Matlacha Pass to reduce flooding due to overland sheet flow from Cecil Webb. However, construction of a high-voltage transmission line and accompanying access road from Punta Gorda southeastward through Cecil Webb has altered the westward flowpaths. Under low flow conditions overland sheetflow runoff can drain through culverts in the access road to the west. Under high water level the access road diverts flow to the southeast. This results in a variable watershed boundary affected by rainfall volume and antecedent water levels.

Each of these primary basins contain several tributaries. There are large tributaries defined by native streams, sloughs and canals. There are many small tributaries that drain small areas adjacent to the C-43. There also are several small tributaries that drain directly to the estuary.

4. WATERSHED HYDROLOGY

The subbasin boundaries are based primarily on the watershed hydrography. Although topography is usually the most important factor affecting sub-basin boundaries, the natural drainage patterns have been substantially altered by ditches. There are few areas in the watershed where the natural drainage has not been changed.

The Hendry County portion of the watershed has been extensively drained for agriculture. Five large canals were dug to eliminate the extensive inundation experienced during the 1950s (COE, 1957). There are several smaller canals that provide additional drainage near LaBelle. Although individual groves have pumped drainage, the regional drainage system is primarily gravity-driven. The eastern end of the watershed, east of Lake Hicpochee, is a large, wet prairie area that was historically a sawgrass marsh with very poor drainage. Much of this area is characterized by muck soil. This region has been systematically ditched to provide drainage. The configuration of the canal system and discharge structures determines the direction of drainage. Much of the area has pumped drainage.

The Lee County portion of the watershed has been ditched to provide drainage for urban development. Several ditches have been constructed that drain directly to the estuary. On the south side of the estuary, flow in these sub-basins is controlled by many weirs and culverts. The eastern extent of the estuarine drainage is bounded by Six-mile Slough and Cow Slough.

On the north side of the estuary in Lee County, the drainage pattern is controlled by native streams and man-made obstructions and ditches. At the west end of the watershed, drainage is controlled by a series of ditches and structures in Cape Coral that were designed to retain freshwater and reduce saltwater intrusion. East of Cape Coral, the native drainage patterns were characterized by overland sheet flow in the higher elevations of Charlotte County that drained through several small streams to the estuary. Drainage from this area is now accelerated by ditches that drain from Charlotte County to the estuary. The result has been to increase the discharge and produce serious flooding.

5. SUB-BASIN HYDROLOGY

The sub-basin boundaries are defined by the sub-basin hydrology which is controlled by landscape relief, native flowpaths, and man-made structures. The native relief forms a shallow east-west valley between the Immokalee Island on the southern edge of the watershed and a high point near Whidden Ranch on the northern extent of the watershed. Although there is a natural north-south gradient with drainage toward the river, there are many areas in the watershed that are essentially flat with little native drainage (Fig. 3). The drainage from these areas can be redirected by slight changes in elevation caused by shallow ditches or roads. In several locations, the result has been a redirection of flow to an adjacent creek producing localized flooding. Throughout the watershed there are locations where the east-west gradient is small, and relatively minor changes in land elevation may redirect runoff into adjacent tributaries.

The sub-basin boundaries may change as a result of urban or agricultural development. Drainage improvements such as berms and ditches have modified both local drainage and disrupted upstream flow patterns. Disruption of flowpaths may be direct; diverting drainage to protect a new development, or subtle; constraining flow that once covered wide marsh into a narrow, eroding stream. This has been a common situation near major roads: SR78, SR80, and SR 29. It also has occurred in the North Estuary watershed. Each new improvement has the potential to modify the sub-basin boundaries.

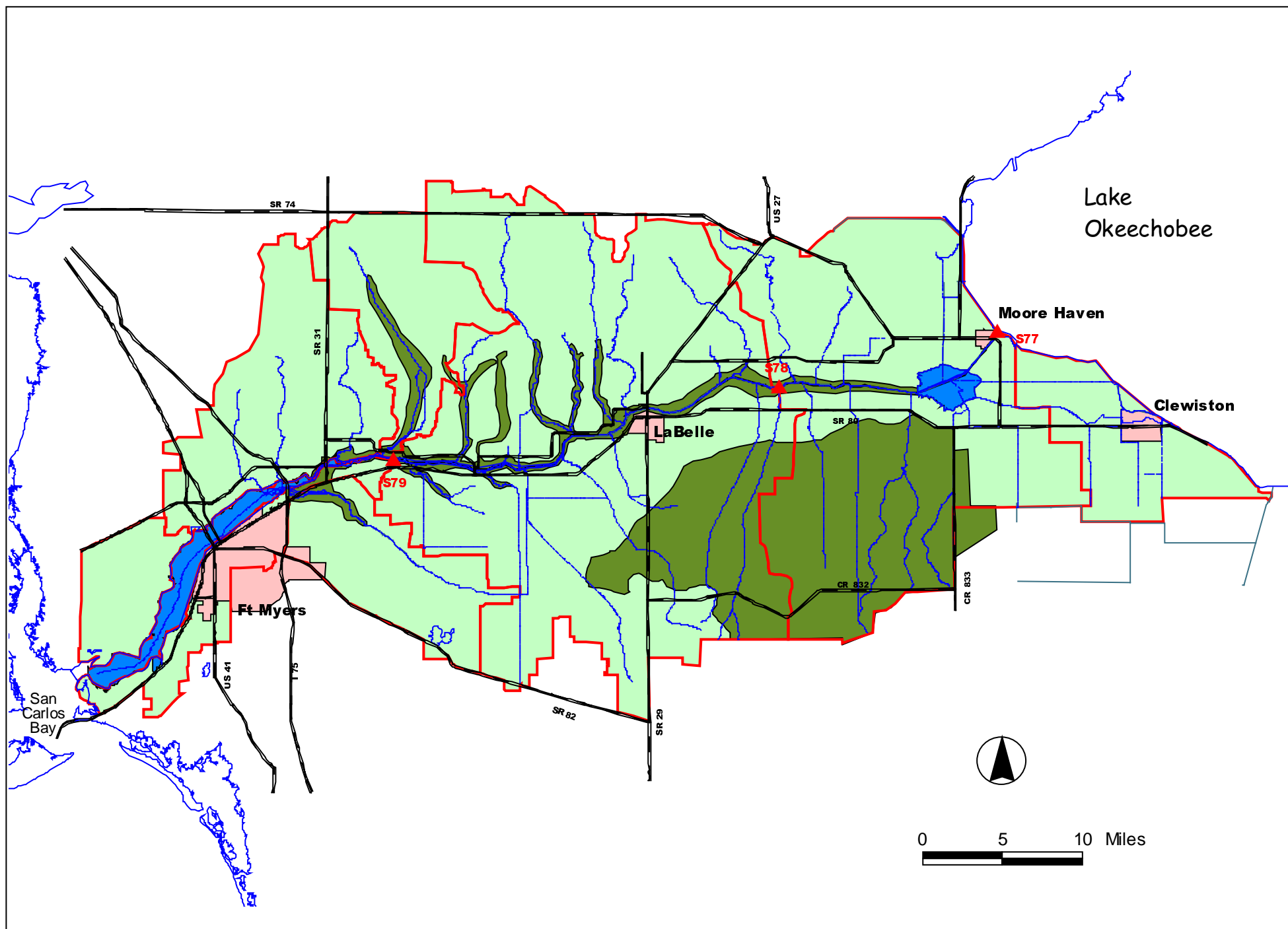


Fig. 3 Areas of prolonged flooding that occurred during 1948, 1951 & 1953.
(adapted from COE, 1957)

The drainage network was established by reviewing the native hydrography, wetlands, and man-made hydrography. It was expected that the published hydrography would be sufficient to define the drainage network. Unfortunately, the 1988 hydrography coverage does not contain sufficient to establish the flow network in the watershed. It was necessary develop a more detailed drainage network based on reviewing the 1994-95 infrared aerial photography. As described in Task 4, all discernable flowpaths that drained substantial areas were identified and included with the current hydrography. The process of identifying and defining the flowpaths resulted in development of drainage network.

6. SUB-BASIN BOUNDARIES

A set of sub-basin boundaries have been developed for the combined East and West Caloosahatchee Basins (CDM, 1994), Cape Coral (USGS, 1991), Lehigh Acres (ATM, 1995), and Lee County (Johnson Eng., 1992). CDM sub-Basins were developed to define the catchment for each of the significant tributaries. The CDM sub-basin boundaries were based on tributary boundaries developed by Miller et al. (1982). Inflows to the Caloosahatchee east of LaBelle are regulated by culverts and pumps on the C-43 canal. The culverts, part of the Central and South Florida Flood Control Project, are maintained by the US Army Corps of Engineers (COE). West of LaBelle the tributaries are primarily free-flowing inflows. A detailed description of these inflows was provided by CDM (1994). There are 147 inflows to the Caloosahatchee River between S77 and S79. However, many of these inflows drain small areas immediately adjacent to the canal and do not constitute individual sub-basins. Forty-two sub-basins

were delineated (Fig. 4). The boundaries for these sub-basins were developed by CDM based on site visits, review of engineering project reports and interpretation of aerial photography.

The sub-basin boundaries for Lee County were developed by Johnson Engineering, Inc. (Johnson Eng. 1992). They determine the boundaries and principle flowpaths for 29 sub-basins that drain to the Caloosahatchee River and Estuary (Fig. 5). These sub-basins were identified as part of the Lee County Stormwater Management Master Plan. The Johnson Engineering, Inc. project did not include the cities of Ft. Myers and Cape Coral. The basin boundaries for Ft. Myers were determined from aerial photography. The sub-basin boundaries for Cape Coral were described by the USGS (1991). The sub-basin boundaries for Lehigh Acres were adapted from drainage studies conducted for East County Water Control District during the 1990s (A.J. Quattrone, personal communication, Jan. 1998). Similar to CDM, the Johnson Engineering study identified several small drainage areas along the estuary that were not considered sub-basins and were lumped into a region of small estuary inflows. Because the Johnson Engineering study was restricted to Lee County the northern extent of these sub-basins in Charlotte County were not completed. These sub-basin boundaries were extended by examining 1994-95 infrared aerial photography. Sub-basin boundaries for southeast Telegraph Swamp and northeast Lee County were modified based on information from the Four Corners study (Craig Smith, 1996).

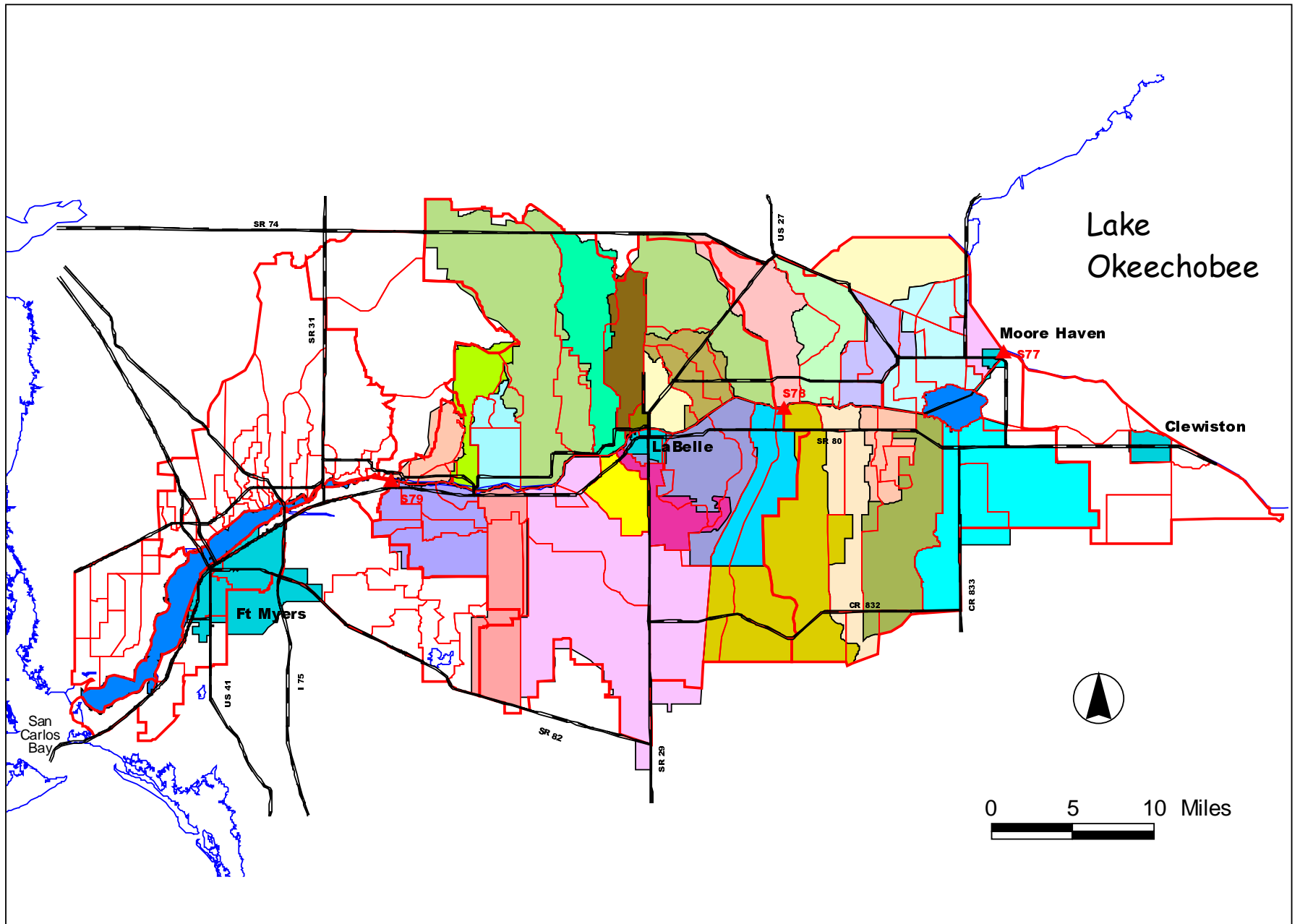


Fig. 4 Sub-basins for the East and West Caloosahatchee Basins (CDM, 1994).

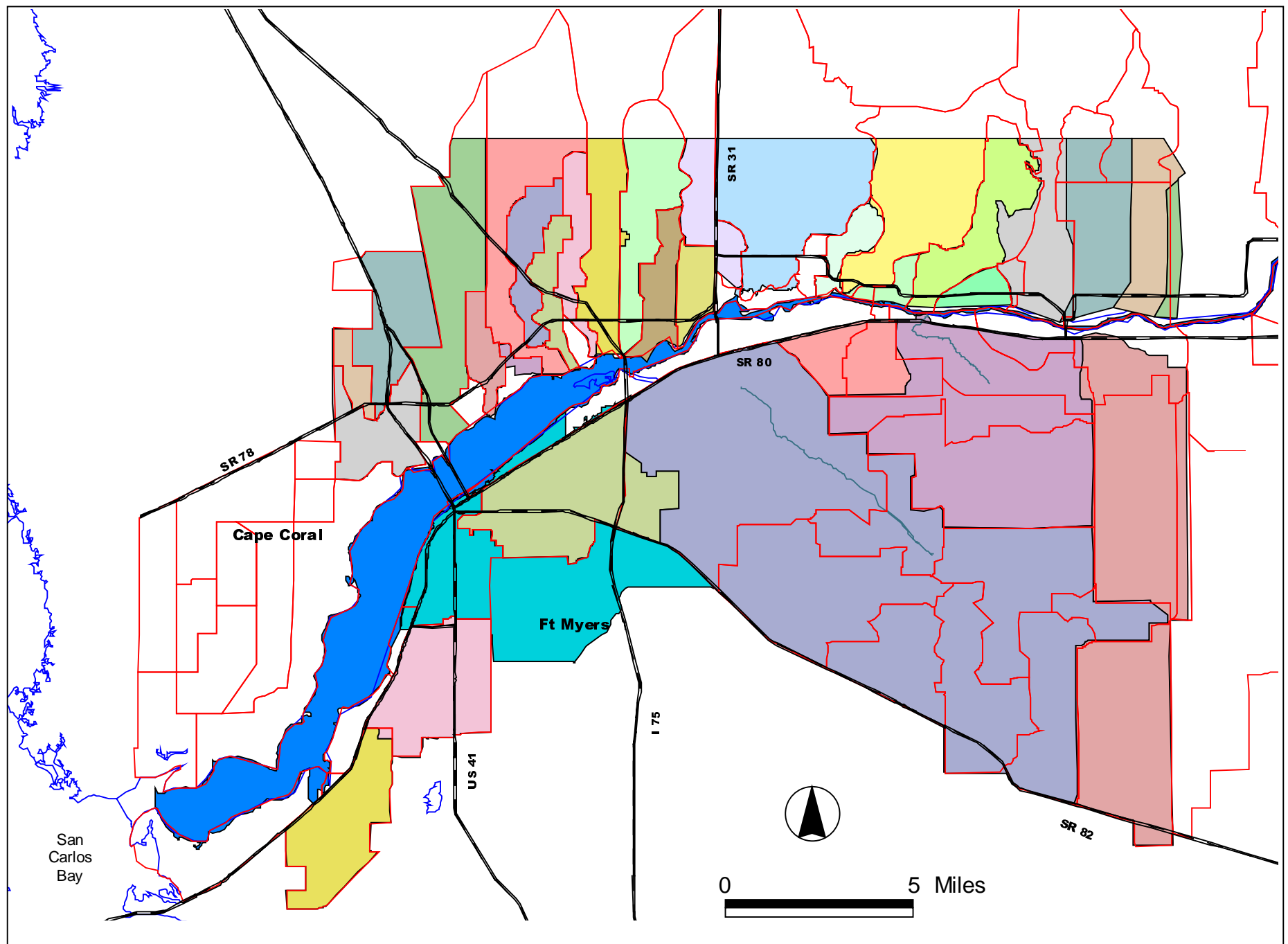


Fig. 5 Sub-basins for Lee County (Johnson, Eng., 1992).

7. VERIFICATION OF SUB-BASIN BOUNDARIES

The sub-basin boundaries were verified using aerial infrared photography, discussions with SFWMD field engineers, and review of surface water permits. The surface water permits indicated where sub-basin boundaries have been changed following the construction of ditches and berms. These changes were confirmed during discussions with field engineers. The engineers also indicated where boundaries were indeterminate due to lack of gradient or the result of flow controls on adjacent land that were set to discharge at different elevations. The discharge from these structures would change the direction of flow by imposing a new water head condition on the landscape. The new boundaries were checked against the previously established boundaries. Where differences occurred a field visit was conducted to review the boundaries. In most cases field trips were possible. For locations where field access was not possible, the boundaries were reviewed using aerial photography.

The sub-basin boundaries were verified independently using aerial photography. The aerial photography was used to determine the drainage network (Task 4). The drainage network was developed by tracing the flowpath from the Caloosahatchee River to the headwaters. The flowpaths were extended from well-defined paths such as streams and ditches to poorly-defined paths such as partially connected wetlands. The poorly-defined flowpaths were confirmed by reviewing soil maps and topography. The drainage flowpaths were extended to the edge of each sub-basin to determine the boundary between adjacent sub-basins. Where the flowpaths could not be extended to

meet the adjacent sub-basin flowpath network, the boundaries were considered indeterminate and the boundaries were drawn midway between adjacent flow networks.

The boundaries developed using the aerial photography were compared to the boundaries developed from the permit review. Where discrepancies existed, the aerial photographs and GIS soils, wetlands, and topographic coverages were reviewed, and using all of these resources together to identify probable flowpaths and flow restrictions, the sub-basin boundaries were delineated (Fig. 6). The sub-basin boundaries for urban Lee County were not checked by field visits. It was felt that there were few changes in the landscape since the Johnson Engineering study was completed and the reported sub-basin boundaries were reasonable.

As indicated in Figure 7, there are minor differences in the sub-basin boundaries. The differences occur along the northern extent of the watershed, Hendry County and the four counties area. The differences along the northern boundary result from changes in land use and additional refinement of the drainage flowpath network. The differences in the sub-basin boundaries in western Hendry County result from changes in land use as well as more detailed evaluation of local drainage patterns. The drainage sub-basin boundaries in the

four-corners region (where all four counties meet) have been carefully examined following flooding problems in that area. Although there remain some discrepancies in the boundaries, they have been changed to reflect the most recent information.

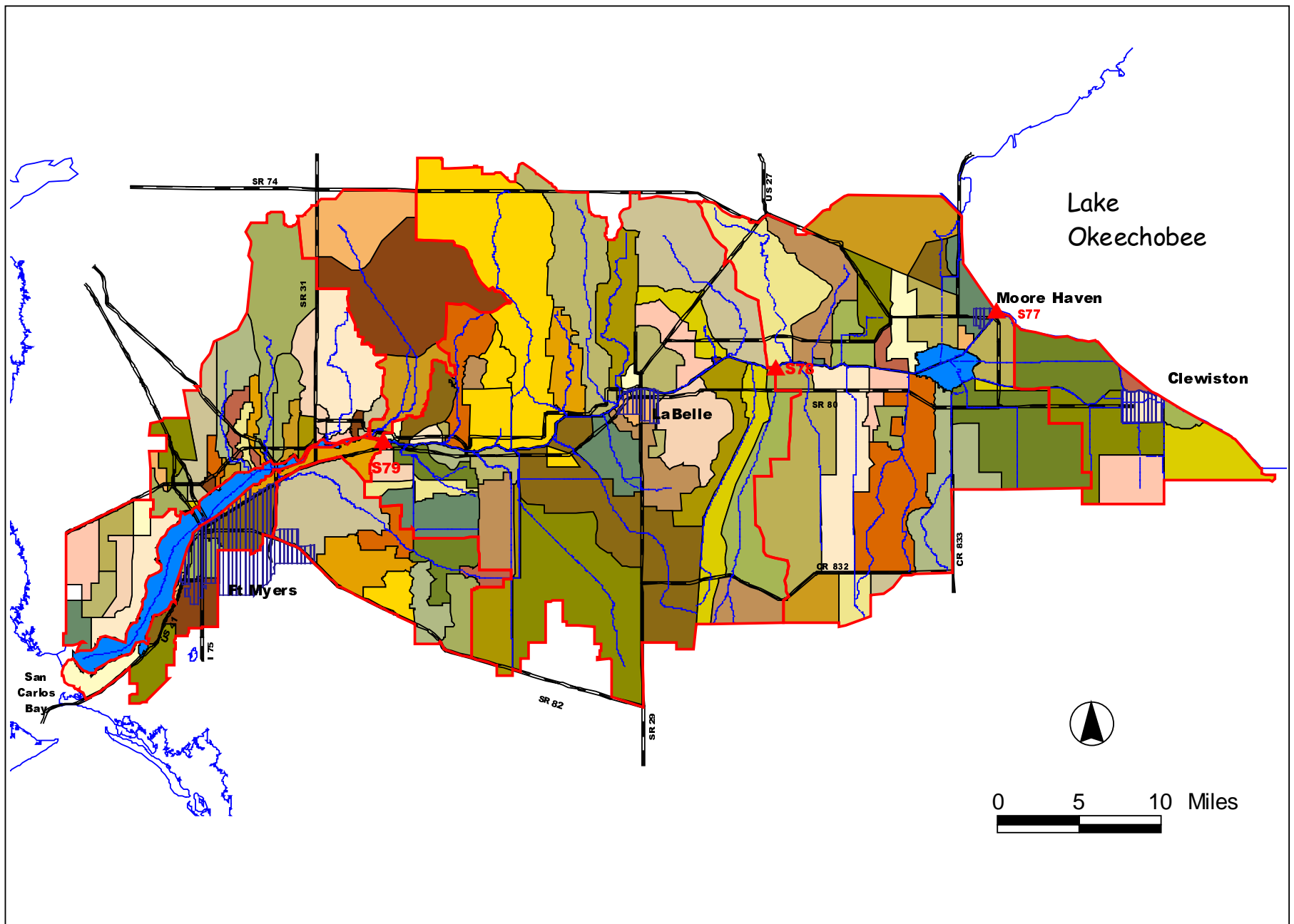


Fig. 6 Modified Sub-basins for the Caloosahatchee Watershed.

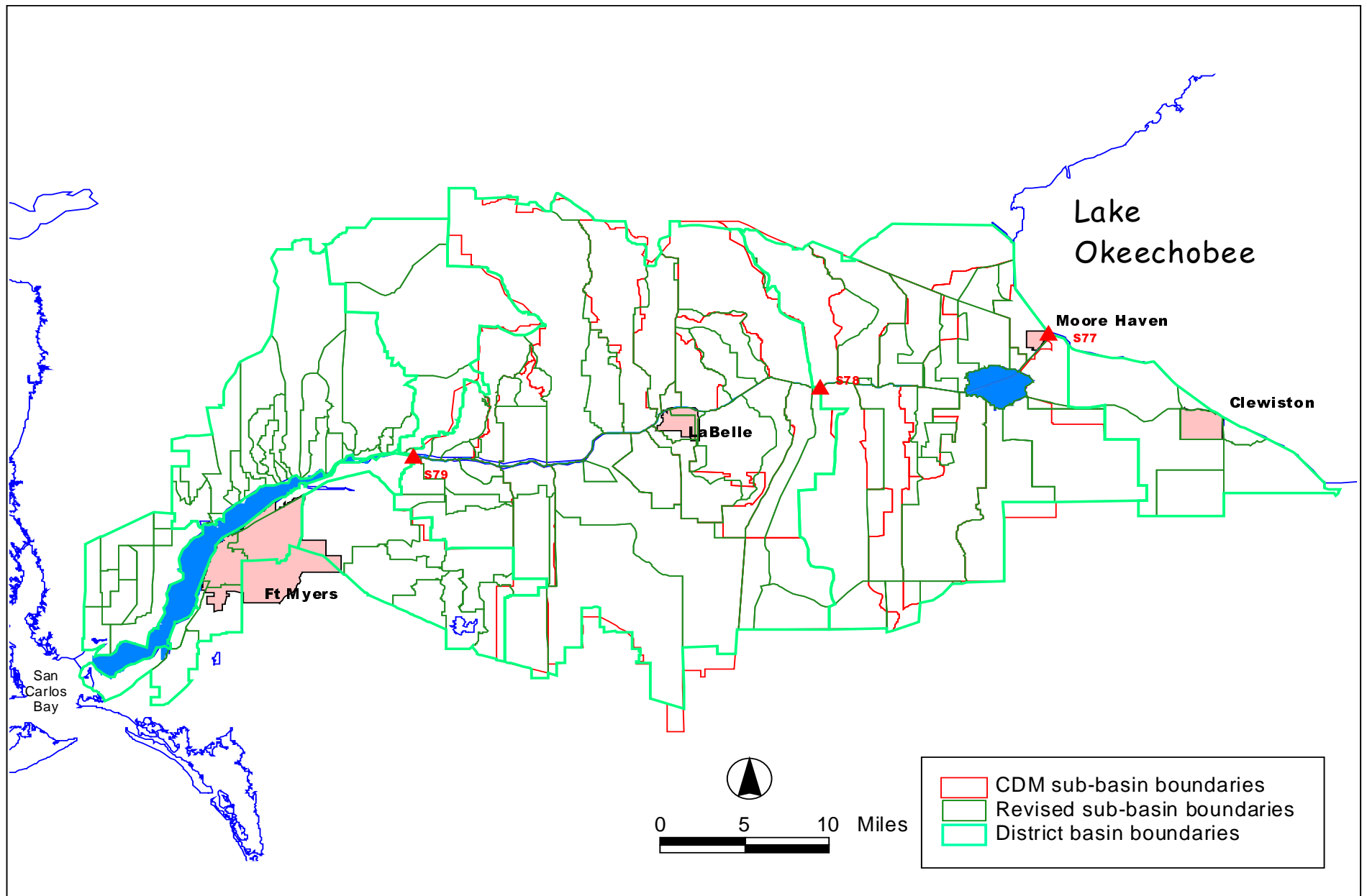


Fig. 7 Revised Sub-basin Boundaries with SFWMD Drainage Basins and CDM Sub-basin Boundaries.

The sub-basin boundaries are subject to errors resulting from ambiguity in landscape drainage and errors due to the inaccuracies of the GIS coverages. The ambiguity in flow patterns occurring as a result of multiple drainage paths and level terrain produce an uncertainty in boundary location that can be as great as 200 ft. Where the boundary follows a berm or road, the probable error in the boundary location is 10-20 ft. In creating the sub-basin boundary coverage, there is uncertainty due to the resolution of the maps and aerial photographs used to locate the boundaries. These sources of uncertainty are in the range of 10-20 ft.; it is not possible to locate any boundary on these coverages with greater precision.

8. REFERENCES

- ATM. 1995. Drainage analysis of East County Water Control District. Unpublished engineering analysis. Applied Technology and Management. Lehigh, FL.
- CDM. 1994. Caloosahatchee River basin assessment. Phase II: Water quality data analysis report. Report to South Florida Water Management District. Camp Dresser & McKee, Inc. Maitland, FL.
- Craig Smith. 1996. Surface water management plan: Four Corners Area. For Hendry County. Craig A. Smith & Associates. Pompano Beach, FL.
- COE. 1957. Central and southern Florida project for flood control and other purposes. Part IV Supplement 6-General design memorandum, Caloosahatchee River and control structures. U.S. Army Corps of Engineers, Jacksonville, FL.
- Johnson, Eng. 1992. Lee County storm water management master plan. Report to Lee County Board of County Commissioners. Johnson Engineering, Inc. Ft. Myers, FL.
- Miller, T.H., A.C. Federico, and J.F. Milleson. 1982. A survey of water quality characteristics and chlorophyll A concentrations in the Caloosahatchee River system, Florida. Tech. Pub. 82-4. South Florida Water Management District. West Palm Beach, FL.
- USGS. 1991. Simulation of the effects of proposed tide gates on circulation, flushing, and water quality in residential canals, Cape Coral, Florida. US Geological Survey Open-File Report 91-237. Tallahassee, FL.

The coverages described in this report are available on the anonymous ftp site at the Southwest Florida Research and Education Center:
<ftp:icon.imok.ufl.edu/pub/wqgis>.